

SCIENCE RATIONALE FOR JUPITER ENTRY PROBE AS PART OF JIMO. R. E. Young¹ and T. R. Spilker², and Participants of the April 21-22, 2003 Entry Probe Workshop, ¹NASA Ames Research Center (Mail Stop 245-3, Moffett Field, CA 94035, e-mail: Richard.E.Young@nasa.gov), ²Jet Propulsion Laboratory (4800 Oak Grove Drive, M/S: 301-165, Pasadena, CA 91109, e-mail: Thomas.R.Spilker-100920@jpl.nasa.gov).

A Jupiter atmospheric entry probe as part of JIMO is a cost effective way to address fundamental science questions identified in the National Research Council Solar System Exploration Decadal Survey (SSEDs): New Frontiers in the Solar System, An Integrated Exploration Strategy. Compared to either the cost of an entirely separate Jupiter mission, or the cost of JIMO itself, inclusion of such a probe on JIMO would be cost advantageous. The probe itself could be relatively simple, and could build on the Galileo Probe heritage.

The SSEDs specifically identified the distribution of water across the Solar System as a Key Scientific

~~Question. Correspondingly, knowing the water abundance~~ Question. Correspondingly, knowing the water abundance on Jupiter is fundamental to understanding almost every aspect of the evolution of the early solar nebula. The Galileo Probe obtained the abundance of several key elements in Jupiter's atmosphere, which data have already caused major rethinking of theories of how Jupiter formed and how the early solar nebula evolved. However, because of a combination of circumstances, the global abundance of the key element oxygen, in the form of water, was not obtained.

Without knowledge of the jovian water abundance, further progress in understanding Solar System evolution and planet formation will be greatly inhibited. Therefore, quantifying jovian water abundance should be a goal of the very next mission to the jovian system. Such a measurement would be impossible via remote sensing from the JIMO orbiter because of the large distances the JIMO orbiter maintains from Jupiter.

A Jupiter atmospheric entry probe as part of JIMO could achieve the fundamental water measurement. In order that a probe avoid repeating the Galileo probe's experience of failing to obtain the jovian water abundance, the probe should go deep, to at least 100 bars pressure. Probes to 100 bars have been accomplished many times in descending to the surface of Venus, and at 100 bars the temperature of the jovian atmosphere is 60-70 K less than the surface temperature of Venus.

In addition to water, there are other desired key compositional measurements that are central to understanding Solar System evolution. Nitrogen abundance in the form NH_3 was a major surprise from the Galileo probe measurements, but measurement uncertainties need to be reduced. Noble gases, in particular Ne, and the D/H ratio, need to be made with greater precision than that obtained by Galileo in order to provide quantitative constraints on possible evolutionary paths.

Such measurements can only be made from an entry probe.

The dynamics of Jupiter's atmosphere has been a puzzle for centuries, and is identified as a Key Question with regard to the outer planets by the SSEDs. The basic question of how deep the observed cloud level winds extend into Jupiter's atmosphere is fundamental to understanding Jupiter's dynamic meteorology, and ultimately that of all the outer planets. This question cannot be addressed from the JIMO orbiter. The Galileo Probe measured high speed winds as deep as it made measurements, to 22 bars, but because of the probe entry location, there is a question as to whether they are local winds or representative of the global wind field. A new probe could avoid this uncertainty, and shed light on a fundamental property of Jupiter's atmosphere to depths of 100 bars or more.

An additional Key Question concerning outer planets identified by the SSEDs is the thermal structure of Jupiter's atmosphere. The associated static stability of the deep atmosphere is a quantity affecting the dynamics, heat transport, and constituent distribution of the planet. Furthermore, it is relevant to understanding the deeper interior structure, as well as tidal dissipation, a quantity directly related to the evolution of the Galilean satellites. The static stability derived from the Galileo probe thermal structure data was, surprisingly, significantly positive all the way to the 22 bar level to which the probe made measurements. If this were to be true in the deeper atmosphere, it would be a major discovery. Only an atmospheric entry probe is capable of making the desired thermal structure measurements in the deep atmosphere.

The likelihood that the above measurements will be made during the next decade if a probe is not part of JIMO depends on the likelihood that NASA will mount another mission to Jupiter apart from JIMO. Time is a consideration for two reasons. First, orderly progress in the field of origins and planet formation requires the knowledge gained by the measurements described above. Second, extrasolar planetary systems are now the subject of intense study, and flight missions dedicated to their characterization will be launched within 4 years. In order to understand extrasolar planetary systems, we must understand our own, and the Jupiter probe measurements described here are vital to that process. A very large scientific gain, part of which would relate directly to the Galilean satellites, can be achieved for a relatively small expenditure of money by including a Jupiter entry probe as part of JIMO.